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ABSTRACT

In this study examining infants' responses to optical expansion, 18 infants between 36 and 61 days old watched expanding shadows that differed in the terminal location of the center of expansion and the number of dimensions undergoing change. Babies consistently rotated their heads upward during expansion of a closed figure when the center of transformation started above their faces and remained there over much of the trial. When the center of change shifted from eye level toward a point below the baby, avoidance (head rotation) was significantly less. Simple horizontal expansion of an open figure was intermediate in its effectiveness. The results are interpreted to mean that infants responded to optical expansion as if they were avoiding an approaching object. Because there were no upward moving contours in the stimulus display, the avoidance could not have been an artifact of tracking. Sensitivity to the apparent path of approach toward or below the face seems to play a key role in determining infants' responses to looming figures. (Author/BD)

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Infants' Responses to Optical Expansion: Avoidance Not Tracking

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Running Head: Infants' Responses

Abstract

~~Infants between~~ 36 and 61 days old watched expanding shadows that differed in the terminal location of the center of expansion and the number of dimensions undergoing change. Babies consistently rotated their heads upward during expansion of a closed figure when the center of transformation started above their faces and remained there over much of the trial. When the center of change shifted from eye level toward a point below the baby, avoidance (head rotation) was significantly less. Simple horizontal expansion of an open figure was intermediate in its effectiveness. The results are interpreted to mean that infants responded to optical expansion as if they were avoiding an approaching object. Because there were no upward moving contours in the stimulus display, the avoidance could not have been an artifact of tracking. Sensitivity to the apparent path of approach toward or below the face seems to play a key role in determining infants' responses to looming figures.

Infants' Response to Optical Expansion: Avoidance Not Tracking

Accounting for visual perception of depth despite a two-dimensional optical stimulus is one of the oldest problems in psychology. Recent theoretical and empirical investigations (e.g. Braunstein, 1976; Gibson, 1966) have suggested that expansion and contraction of a stimulus are powerful sources of information about movement toward and away from an observer respectively. Perceived movement in depth is a primary phenomenon, according to these investigators, in that observers tend strongly to see movement in depth rather than mere size or form changes when a stimulus undergoes a transformation.

Developmental work suggests that infants under 8-weeks-old use optical expansion as a source of information in seeing movement of surfaces in depth. Bower, Broughton, and Moore (1970) found that 2-week-old babies withdrew their heads up and away from an approaching real object or its two-dimensional equivalent, a symmetrically expanding shadow. Ball and Tronick (1971) replicated these findings and extended them in showing that babies' avoidance was specific to direct approach. Real objects moving toward a baby but off to one side and asymmetrical expansion of shadow both resulted in few instances of avoidance. The results have been interpreted (Ball, 1976) as consistent with Gibson's (1966) view that optical transformations provide information to humans about distal events such as collision with a surface. Infants' perception of approach seems to depend on a precocious ability to detect and use optical magnification specifying movement in depth.

Yonas, Bechtold, Frankel, Gordon, McRobert, Norcia, and Sternfels recently (1977) challenged the view that infants under 8 weeks avoid approaching objects or expanding shadows. They found that babies rotated their heads up and away from a contour that simply moved up a "slot" in a projection screen. Furthermore, expansion of a shadow with its top contour remaining at eye level failed to produce avoidance (head withdrawal or rotation). Yonas et al. concluded that the "avoidance" observed by Bower et al. (1970) and Ball and Tronick (1971) was an artifact of tracking a contour moving upward in the visual field.

At least two lines of evidence make the Yonas et al. interpretation implausible. Working with babies between 3 and 6 weeks old, Ball and Vurpillot (1976) found that an expansion pattern consisting of discrete elements yielded consistent rotation of the head up and away from the projection screen. Tracking a single contour upward was unlikely as there were over 800 circles in the visual display. Also, Bower (1977) noted that withdrawal (measured by changes in the force with which babies pushed against a seat) was consistently obtained even when downward movement of the top contour of the expanding shadow was present!

Thus, it is unlikely that an infant's pulling away from an expanding shadow or approaching object can be reduced to mere following of a contour. That babies can track contours does not mean that they do so during expansion of a stimulus. A problem remains, however, Why did the babies in Yonas et al.'s study (1977) fail to rotate their heads away from the screen when the top contour of the shadow remained at eye level?

An answer to the question perhaps lies in the specificity of avoidance

to conditions of direct approach of a real or virtual object (Ball & Tronick, 1971). It is possible that in Yonas et al.'s study (1977) the constant downward movement of the center of the shadow specified movement of an object toward a point below the baby's face. The perception may well have been one of an object going to miss the eyes. The present study included a test of this possibility. In one condition, expansion of a shadow in the shape of a diamond was begun above the baby's head so that the geometric center of the object terminated near eye level. It was predicted that the frequency of head rotation up and away from the screen would be greater than during expansion beginning at eye level--if the path of approach were crucial to the occurrence of the response. Of course, the vertex of the shadows remained at a constant level throughout all transformations.

A third condition was used to assess whether expansion of "open" figures would produce avoidance. A shadow lacking top and bottom contours was enlarged such that only its horizontal contours were seen to move. The result was a "one-dimensional" (horizontal) change which adults (Johannson, 1964) do not consistently report as looking like movement in depth. No specific predictions were made as to its relative effectiveness. It should be noted that any avoidance in the third condition would not have been due to "tracking." There were no top or bottom contours to follow.

Method.

Subjects. A total of 24 full-term infants visited the laboratory, but 6 were unable to complete the session because of sleeping, crying, or equipment failure. The final sample of 18 infants consisted of 10 girls and

8 boys, ranging in age from 36 to 61 days (mean age = 47 days). Infants' names were obtained from birth announcements in a local newspaper. Parents were sent a general description of the work in the mail, and they returned a postcard if willing to participate.

Material and Stimuli. The experimental space consisted of a darkened room containing a plastic rear projection screen (156 cm X 156 cm) and a motorized, overhead pulley system for shadow casting (see Ball & Tronick, 1971). A light source (Tung-Sol, 6-8 v bulb) was placed 106 cm from the screen, and shadows were cast by opaque objects suspended from the pulley system. Transformations were generated by driving the objects toward the light source at a constant speed of 11.13 cm/sec. The shadow caster always travelled a total of 68 cm, so that all transformations lasted 6 seconds.

For the shadow casting two different objects were used. The first was a styrofoam cube (6.5 cm on a side) suspended from the pulley system by a 1/4 inch dowel rood. The cube was oriented as a diamond with respect to an upright observer. At 25 cm from the projection screen, the visual angle subtended by the shadow ranged from 20 to 99 degrees during a transformation. The second object was a cylinder (8.5 cm X 100 cm) suspended between the source of light and the screen. The shadow had no visible top or bottom, because the top edge was projected above the screen and the bottom contour was hidden by the infant seat. During a transformation, the visual angle ranged from 24 to 99 degrees.

Three different stimulus transformations were used. In the first, the diamond-shaped object was placed so that its bottom edge was about 10 cm

above a baby's head. The top edge of the shadow always remained at a constant height above the infant. Moving the object toward the light resulted in a two-dimensional expansion of the shadow - outward and downward - such that its center finished approximately at the baby's shoulder level. A second transformation was identical to the first except that the top edge of the shadow remained near the baby's eye level, with the center of the shadow descending below the infant seat. The third transformation, generated by moving the cylinder toward the light source, appeared as a horizontal expansion of the two contours of the shadow. No change in the vertical dimension of the shadow was visible to the baby (hence the label "one dimensional change"). Contractions of all stimuli were produced by moving the shadow caster away from the light source at the same rate as during expansion.

The baby's responses were recorded on videotype via a television camera placed 1 meter to the infant's left. Light from an incandescent bulb (75 w) provided sufficient illumination for operation of the video recorder without compromising the clarity of the shadow.

Procedure. Babies were brought to the laboratory by their parents, who were first shown a transformation and told the purpose of the study in general terms. The specific hypotheses were not stated until the end of the session. After signing a consent form, the parents placed the baby on his back in a cushioned car seat and strapped him in across the thighs. The seat was then tilted such that the baby sat upright directly in front of the shadow. The baby was held around the waist by a parent standing behind the seat such that the baby's head and arms were free to move.

When the baby's attention seemed directed to the shadow, the series of trials was begun. Subjects saw each type of transformation in sets of three cycles of expansion and contraction of the stimuli. The order in which babies saw the three blocks of three cycles was determined by a Latin square; a total of 6 babies were assigned randomly to each of the three stimulus orders. A complete cycle consisted of an expansion of the shadow for 6 seconds, then a pause of at least 10 seconds, and finally, a contraction of the shadow during 6 seconds. After an additional pause of 10 seconds, another expansion was begun. Babies thus saw a total of nine expansions and nine contractions over the entire session. During adjustment of the equipment for a new type of stimulus transformation, the baby was returned to a horizontal position. Transformations were begun only after it was judged by the experimenter that the baby was calm and watching the shadow. The baby's attention was captured prior to a trial by a rattle which was removed before the expansion or contraction began. Babies who fussed were usually removed from the infant seat to calm them down between trials.

A technique patterned after that of Yonas et al. (1977) was used to score the infant's head movements during expansions and contractions of the stimuli. A plastic protractor divided into intervals of 10 degrees was placed on the television monitor such that the origin was on the image of the baby's ear and the 0-180° axis intersected the ear and nose. Rotations of the nose above this axis were scored 0 if the change in angle were 0-10°; +1 for changes of 11-20°; +2 for rotations of 21-20°; and +3 for all other upward rotations. Comparable negative scores were assigned to head rotations in which the baby's nose went below its position at the start

of the trial (0 being counted for deviations of 0- -10°). Each expansion and contraction trial was scored. For every stimulus condition, a baby was thus given two scores, one based on the algebraic sum of the ratings for the three expansion trials and the other based on the sum across three contraction trials. For example, the maximum possible score per baby for expansion trials within the "one-dimensional" condition was +9.

Results

The results are presented in three sections: 1) expansion trials, 2) contraction trials and 3) comparison of expansion and contraction trials.

Expansion. Comparison of the stimulus conditions was first conducted in the absence of any order effects due to repeated measures on more than one type of stimulus. The first three expansion trials of each of the stimuli were examined using a one-way analysis of variance with 6 infants in each condition. The results were significant and in the predicted directions, F (2,15) = 7.90, $p < .01$. Planned comparisons (two tails) indicated that the two-dimensional expansion starting above head level was more effective in producing positive head rotation than either the stimulus having its top contour at eye level (t (15) = 3.9 $p < .01$) or the one-dimensional transformations (t (15) = 2.64 $p < .02$). The latter two conditions did not differ significantly. Thus, there was a pattern of greater positive head rotation during two-dimensional changes beginning above head level than those starting at eye level or merely involving horizontal expansion.

Insert Table 1 about here

The generality of the results across all 18 babies was assessed with a repeated measures analysis of variance. The results were straightforward: There was again a significant effect of the stimulus condition, F (2,34) = 3.66, $p < .05$. Planned comparisons revealed that the two dimensional transformation beginning above head level produced significantly greater positive head rotation than the two-dimensional change starting at eye level ($P < .05$). The horizontal expansion was intermediate in

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Insert Table 2 about here

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effectiveness, not differing significantly from either of the two-dimensional transformations. The basic prediction of the study was confirmed, however: Expansion beginning above the head produced more withdrawal than expansion beginning at eye level.

Contraction. The data from the contraction trials were subjected to the same analyses as those of the expansion trials. The results were clear: No significant effects were obtained, whether over the whole experiment or in the first three trials (see Tables 1 and 2). Thus the differential effectiveness of the two-dimensional transformation was restricted to expansion trials, i.e., conditions specifying approach.

Direct comparison of expansion and contraction trials. For each stimulus condition, the babies' data were examined to see whether upward head rotation during expansion was generally greater than during contraction. Across all 18 babies, this was the case for each stimulus (all three sign tests significant at $p < .02$). Expansion resulted in consistently greater positive head rotation than contraction, a result which replicated data

data furnished by Ball and Tronick (1971) and Ball and Vurpillot (1976).

Discussion

The results of the present study confirm earlier reports that young babies avoid expanding shadows as if they were approaching objects (Ball and Tronick, 1971; Ball and Vurpillot, 1976; Bower, Broughton and Moore, 1970). Upward head rotation was consistently greater during conditions corresponding to the approach of an object (optical expansion) than conditions specifying movement away (contraction). The avoidance was not an artifact of tracking: In no case did expansion involve a contour moving vertically upwards. Upward rotation could not have represented following of a moving edge, because contours only moved left, right and sometimes down.

The ineffectiveness of the eye-level condition in the present work replicated the results of Yonas et al., suggesting that the experimental procedures were comparable. The ineffectivness is best seen, however, not as a failure in tracking but the outcome of ambiguous information for collision with the face. As in the Ball and Tronick work (1971) with shadows moving to the subjects' left, the babies' avoidance in the present work varied with the likely end point of the apparent movement in depth. A two-dimensional expansion having its top edge remain above the baby's head resulted in more avoidance than a two-dimensional change starting at eye level. The center of expansion as a source of directional information was probably crucial to the effects. As Gibson has noted (1966), a shift in the center of an optical expansion specifies movement of an object to one side of the point of observation. When the shadow expanded outward and downward from a fixed position at eye level, the center of expansion

rapidly shifted below the face. With the shadow starting above the head, however, the center of expansion actually shifted to the eye level and remained in the general head region during much of the transformation. Hence, the optical expansion more clearly specified that the face was probably in the path of the movement in depth. Babies thus seem to perceive both apparent movement of a surface in the third dimension and its direction of approach; the path of approach must clearly specify potential collision with the face in order for avoidance to occur.

The importance of the dimensionality of the stimulus changes is less clear. During the first trials of a session, the horizontal expansion was relatively ineffective. Over the entire experiment, however, the horizontal expansion was not significantly less effective than a two-dimensional change. Babies often saw horizontal expansion after two-dimensional transformations, and it is possible that avoidance obtained with the former was due to "generalization" from the two-dimensional case to any expansion centered on the face. Additional research is planned to examine explicitly the importance of the type of expansion a figure undergoes. That horizontal expansion can result in more withdrawal over an entire experiment. than one-dimensional contraction further suggests that the avoidance is not merely an artifact of upward tracking.

In sum, it is possible to agree with Braunstein (1976) that perceived depth tends to be the norm with transforming stimuli, and cues to the actual flatness of the screen may have to be learned before the expansion is not seen as <u>real</u> movement in depth. Stimulus transformations are powerful sources of information about distal motion, and infants too young to crawl or reach systematically for objects perceive approach of a surface along the line of sight.

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Footnotes

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TABLE I

MEAN TOTAL HEAD ROTATION OVER TRIALS 1-3

	Above Head	Eye Level	One Dimensional
Expansion	7.17 (2.54)	1.0 (4.28)	3.0 (1.53)
Contraction	.17 (4.56)	1.50 (1.61)	2.17 (3.53)

Note. Scores can range from -9 to +9 and n = 6 for each condition. Standard deviations are in parentheses.

TABLE 2

MEAN TOTAL HEAD ROTATION OVER ENTIRE EXPERIMENT

	Above Head	Eye Level	One Dimensional
Expansion	5.56 (3.47)	2.67 (3.86)	4.28 (2.78)
Contraction	0.17 (3.79)	0.21 (2.87)	1.50 (2.58)

Note. Scores can range from -9 to +9 and n = 18. Standard deviations are in parentheses.